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Job burnout is associated with dysfunctions in brain mechanisms of voluntary and involuntary attention

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Highlights

- We studied attention-related ERPs in burnout
- Orienting to distractor sounds is reduced in burnout when working memory is taxed
- Task-related decrease in posterior and increase in frontal activity was observed

Abstract

Individuals with job burnout symptoms often report having cognitive difficulties, but related electrophysiological studies are scarce. We assessed the impact of burnout on performing a visual task with varying memory loads, and on involuntary attention switch to distractor sounds using scalp recordings of event-related potentials (ERPs). Task performance was comparable between burnout and control groups. The distractor sounds elicited a P3a response, which was reduced in the burnout group. This suggests burnout-related deficits in processing novel and potentially important events during task performance. In the burnout group, we also observed a decrease in working-memory related P3b responses over posterior scalp and increase over frontal areas. These results suggest that burnout is associated with deficits in cognitive control needed to monitor and update information in working memory. Successful task performance in burnout might require additional recruitment of anterior regions to compensate the decrement in posterior activity.

Keywords: Job burnout; Attention; Event-related potentials (ERP); P3a; P3b

Introduction

Job burnout is a work-related chronic affective state, developing gradually over time as a consequence of prolonged stress at work. Usually it is characterized by emotional exhaustion, cynicism, and decreased effectiveness and professional inefficacy (Maslach, Schaufeli, & Leiter, 2001; Schaufeli & Enzmann, 1998). Disturbed sleep, physical fatigue, and cognitive weariness are typical of job burnout (Ekstedt et al., 2006; Melamed et al., 1999). The symptoms overlap considerably with depression and psychological distress, especially in the more severe forms of job burnout but there is an increasing body of evidence supporting the argument that burnout and depression are not identical concepts (Ahola, Hakanen, Perhoniemi, & Mutanen, 2014; Bakker et al., 2000; Brenninkmeyer, Van Yperen, & Buunk, 2001; Iacovides, Fountoulakis, Kaprinis, & Kaprinis, 2003; Marchand, Durand, Juster, & Lupien, 2014).

Individuals who experience job burnout often report having cognitive difficulties. To date, the impact of burnout on cognitive processes has been mainly assessed through behavioral studies, which suggest an association with impairments in voluntary control of attention (Linden, Keijsers, Eling, & Schaijk, 2005; Sandström, Rhodin, Lundberg, Olsson, & Nyberg, 2005), processing speed (Österberg, Karlson, & Hansen, 2009), and working memory (Oosterholt, Van der Linden, Maes, Verbraak, & Kompier, 2012). However, these results have been found mostly in clinical samples with high levels of burnout. In fact, in a population-based study of young adults with relatively mild symptoms, no association between self-rated symptoms of burnout and cognitive difficulties was observed (Castaneda et al., 2011). So far, only a few related electrophysiological studies have been published suggesting reduced allocation of attentional resources to the task at hand (van Luijckelaar, Verbraak, van den Bunt, Keijsers, & Arns, 2010), and more recently, an attention capture tendency towards negative over positive emotional sounds in individuals who complain of job burnout (Sokka et al., 2014). In the present study, we extend our previous work by measuring event-related

brain potentials (ERPs) to task-relevant visual stimuli in tasks with varying memory loads as well as task-irrelevant distractor sounds (no response required) in participants suffering from job burnout and in their matched non-burnout peers.

We used the *n*-back task, in which the participants are asked to monitor a series of stimuli and to respond if the incoming stimulus matches to the one presented *n* trials before (Owen, McMillan, Laird, & Bullmore, 2005). Typically, an increase in memory load increases response time and decreases accuracy (e.g., Smith & Jonides, 1997). Task-relevant stimuli elicit a P3b response, peaking approximately at 300-500 milliseconds after stimulus onset, and reflecting brain activity related to context updating (Picton, 1992; Polich, 2007; Soltani & Knight, 2000). Neuroimaging studies indicate that working memory updating gives rise to significant load-dependent activation on a widespread fronto-parietal network, including the dorsolateral prefrontal cortex, posterior and inferior regions of the frontal cortex, and the posterior parietal cortex (Alain, Shen, Yu, & Grady, 2010; Carlson et al., 1998; Cohen et al., 1997; Leung & Alain, 2011; Owen et al., 2005; Smith & Jonides, 1997).

It has been argued that P3b is sensitive to the demands placed on working memory as reflected by reduced responses over parietal and central regions (Wintink, Segalowitz, & Cudmore, 2001).

Decrement of the P3b at centro-parietal regions was also demonstrated in the study of Pratt, Willoughby, and Swick (2011) but only in task conditions where task-irrelevant stimuli were present. In addition, there is evidence of P3b being susceptible to stress as well as fluctuations in the participant's level of arousal, tending to decrease in amplitude in conjunction with higher stress (Shackman, Maxwell, McMenamin, Greischar, & Davidson, 2011), fatigue, or low arousal state stemming from sleep disruption (Colrain & Campbell, 2007; Polich & Kok, 1995).

Unexpected novel sounds elicit a P3a response, which is thought to index involuntary capture of attention (Alho et al., 1998; Escera, Alho, Winkler, & Näätänen, 1998; Friedman, Cycowicz, & Gaeta, 2001; Knight, 1984; Knight, Scabini, Woods, & Clayworth, 1989), as such sounds also cause a delay in participants' responses to task-relevant stimuli (Escera et al., 1998; Escera, Yago, & Alho, 2001; Escera & Corral, 2007). Studies using the auditory-distraction paradigm, i.e., participants are instructed to perform a visual task and ignore the concomitant auditory stimulation, have identified two distinct consecutive phases – early and late – of the auditory P3a response, peaking approximately 230 ms and 320 ms after stimulus onset, respectively (Escera et al., 1998; Winkler, Denham, & Escera, 2015; Yago, Escera, Alho, Giard, & Serra-Grabulosa, 2003). The scalp distribution of the P3a is more anterior than that of the P3b suggesting different neural generators (Escera et al., 1998; Friedman et al., 2001; Knight et al., 1989; Knight, 1997; Schröger, Giard, & Wolff, 2000; Soltani & Knight, 2000). The auditory P3a is generated by a widespread network of cortical regions, including the prefrontal cortex, the auditory cortex, temporo-parietal junction, medial frontal gyrus, and anterior cingulate gyrus (Alho et al., 1998; Friedman et al., 2001; Knight, 1984; Knight et al., 1989). Further, the early phase of the P3a is maximal over temporo-parietal and fronto-temporal locations, whereas the later phase has a wider distribution spreading towards prefrontal and superior parietal regions (Escera et al., 1998; Yago et al., 2003). When the task requires working memory, the memory load modulates the distraction caused by the stimuli irrelevant for the task (Berti & Schröger, 2003). As working memory load increases, distraction reduces behaviorally, and P3a responses elicited by the novel sounds diminish in amplitude, especially the later phase of the P3a response (SanMiguel, Corral, & Escera, 2008). Furthermore, P3a, like P3b, has also been suggested to attenuate in amplitude due to sleep deprivation (Colrain & Campbell, 2007).

To sum up, previous research findings on burnout suggest that cognitive weariness, disturbed sleep, and psychological distress are typical of burnout. In addition, previous ERP studies have suggested

that the P3a and P3b responses are susceptible to stress and fatigue. Therefore, we should observe a group difference in electrophysiological activity elicited by both the task-relevant visual stimuli and the distractor sounds not relevant to the task. More specifically, we hypothesize smaller auditory P3a and visual P3b responses in the burnout group. Previous behavioral studies have reported differences in cognitive processes, however mainly in severe burnout. Thus, we might observe comparable task performance between those with job burnout symptoms and those without symptoms as our sample is non-clinical in nature reporting a wide range of burnout symptoms, however relatively mild on average.

Methods

Participants

The participants in the present study were the same as reported in Sokka et al (2014) except for one participant who did not complete the n-back paradigm, resulting in a total of 66 participants. The grouping of the participants into the burnout and control groups was implemented as follows: the Finnish version of the Maslach Burnout Inventory – General Survey (MBI-GS; Kalimo, Hakanen, & Toppinen-Tanner, 2006) was completed after the ERP recordings, and used as a grouping criterion (cut-off point: the total score 1.5, i.e., at least mild job burnout). The groups resulted in no clear differences in age, gender, education, and working experience (see Table 1). Based on the exclusion criteria of the EEG analysis (see “Electrophysiological recording and analysis” section for more detailed information), a final sample of 30 participants with job burnout (mean age = 47.5, SD = 8.2 years, 2 left-handed) were compared with a sample of 19 non-burnout control participants (mean age = 43.3, SD = 8.7 years, 1 left-handed). Data from 17 participants (10 job burnout, 7 control participants) were discarded due to excessive artifacts, or technical difficulties. All participants had self-reported normal hearing, and normal or corrected-to-normal vision. The participants were recruited from among customers of the Occupational Health Centre of the city of Helsinki and employees of the city of Helsinki through advertisements displayed at the local

occupational health care station, as well as on the intranet sites of the aforementioned organizations. Of the job burnout participants, 80% entered the study after noticing the advertisement, and 20% were referred by a physician, psychologist, or nurse during appointments at the local occupational health care station. The participants were at work, they reported encountering cognitively demanding situations in their daily work (e.g., interruptions), and they worked only during daytime (i.e., shift workers were included but night-shift workers were excluded). Other exclusion criteria were (i) excessive use of alcohol (i.e., 40 g of alcohol or more regularly per day for men, 20 g of alcohol or more per day for women; Alcohol: Current Care Guidelines, 2011) or drugs, (ii) diagnosed severe psychiatric or neurological disorders, and (iii) schizophrenia in first grade family members. Also other diagnosed illnesses of organic origin resulting in fatigue, such as an organic sleep disorder or severe anemia, were considered exclusion criteria.

Materials

Self-reports

In the beginning of the whole ERP session and just before the start of the n-back task (approximately one hour from the onset of the recording session), the participants were asked to rate their subjective sleepiness on the 9-point Karolinska Sleepiness Scale (KSS; Åkerstedt & Gillberg, 1990). The MBI-GS (Kalimo et al., 2006; scoring range 0-6) comprises three subscales: exhaustion, cynicism, and professional inefficacy. According to the instructions provided in the MBI-GS manual, the scores from the subscales were used to calculate the total score. MBI-GS is a widely used tool for research as it maintains a consistent factor structure across a variety of occupations (Leiter & Schaufeli, 1996; Schutte, Toppinen, Kalimo, & Schaufeli, 2000). The internal consistency of the MBI-GS in the present sample was 0.88 as measured with Cronbach's alpha. In addition, the following clinical measures were completed: the Finnish versions of Beck's Depression Inventory (BDI-II, scoring range 0-63; Beck, Steer, & Brown, 1996; Finnish norms, 2004) and Beck's Anxiety Inventory (BAI, scoring range 0-63; Beck & Steer, 1990), a modified version of the Basic Nordic

Sleeping Questionnaire (BNSQ, scoring range 0-11; Partinen & Gislason, 1995), as well as a questionnaire concerning possible current medication for sleep disturbances and mood disorders.

n-back task

Visual stimuli were bright white numbers (0-9) on a black background (static contrast ratio 1000:1), presented in the centre of a computer screen subtending a visual angle of $1^\circ \times 1.9^\circ$ at a distance of 80 cm in front of the participant. Stimulus duration was 500 ms, and the stimulus-onset asynchrony (SOA; the amount of time between the onset of one stimulus and the onset of the next stimulus) was 2000 ms. During the delay period a black screen was visible. The participants completed a visual n-back task consisting of 0-, 1-, and 2-back conditions. The conditions were presented in the same order (0-1-2) for all participants. In the 0-back condition, participants indicated whether the incoming stimulus was a predetermined '5' (match; button press with right index finger) or any other stimulus (non-match; button press with left index finger). In the 1-back condition, their task was to determine whether the current number was the same (match) or not (mismatch) as the previous one. In the 2-back condition, each stimulus was compared with the stimulus presented two trials before. Each condition consisted of a total of 212 stimuli delivered in a random order except that 33% of them were matches and 67% mismatches in a given n-back task (Figure 1).

During the visually presented n-back conditions, participants were presented with complex environmental distractor sounds, such as those produced by a hammer, drill, telephone ringing, door, rain etc. The sounds were the same as used by Escera and colleagues (Escera et al., 1998; Escera, Yago, Corral, Corbera, & Nunez, 2003). Each complex sound was presented only once. Ninety-six most identifiable novel sounds according to the classification of Escera and colleagues (2003) were used, thirty-two in each condition, once every 10-16 seconds. Sounds were presented via two loudspeakers (Genelec, Iisalmi, Finland) placed on the wall of the chamber at a height of 160 cm and at a distance of 130 cm from the participant. The loudspeakers were placed at

approximately 50 degrees to the left and right of the participant. Sound duration was 200 ms, and intensity was 57 decibels (dB) sound pressure level (SPL) on average, and it was measured with an SPL meter placed at the position of the participants head. The experiment was constructed and presented with Presentation software (Neurobehavioral Systems, Inc., version 14.9). Prior to each condition, participants were presented with written instructions and a practice trial to familiarize themselves with the tasks. Between conditions, the participants had a brief break. Task performance, i.e., accuracy and reaction times (RTs), was recorded. Participants did not receive feedback on their performance.

Procedure

The participants were first interviewed by telephone to ensure that the potentially experienced symptoms of burnout are work-related. The questions asked covered for example the symptoms and their onset, possible psychiatric or neurologic diagnosed illnesses (exclusion criteria), other possible etiology for the symptoms, working experience, and employment status. After they were recruited, an appointment was made for the participation in the study. The participants were tested individually in two sessions, one consisting of measurements of ERPs in five different paradigms, and the other of neuropsychological assessment. The participants were given the opportunity to attend the sessions consecutively within one day or on two separate days, according to their preference. Within 1-2 months after the sessions, the participants were offered a possibility to get individual feedback on their performance in the neuropsychological assessment. During this visit, the participants were given a possibility to discuss their work situation with a psychologist (the corresponding author) and a neurologist from the Finnish Institute of Occupational Health.

One of the ERP paradigms, the n-back task, is reported here. The ERP recording sessions were always carried out before noon, lasting 2-2.5 hours including breaks. The present task began approximately 90 minutes after the onset of the ERP session, and the recording time was 30

minutes. Written informed consent for participation was obtained from all volunteers before entering the study. The protocol followed the Declaration of Helsinki for the rights of the participants and the procedures of the study. An ethical approval of the present research protocol was obtained from The Ethical Committee of the Hospital District of Helsinki and Uusimaa (HUS). All participants were given a book gift and a gift card for their participation in the study.

Electrophysiological recording and analysis

The EEG recording was carried out in a soundproof chamber where the participants were comfortably seated at an office workstation. They were instructed to blink as little as possible, to concentrate on the visual n-back task, and to ignore the auditory stimuli. The EEG was recorded continuously at 500 Hz using a 32-channel active electrode system (actiCAP, Brain Products GmbH, Gilching, Germany) connected to a neurOne amplifier (Mega Electronics Ltd, Kuopio, Finland). EEG was recorded from 26 electrodes placed according to the extended international 10-20 electrode system (excluding channels O1, O2, TP9, TP10, PO9, and PO10). The common reference and ground were located at FCz and AFz, respectively. Two additional electrodes were placed at the left and right mastoids to allow re-referencing in later analyses. In addition, bipolar horizontal electro-oculogram (HEOG) was recorded between two electrodes placed on the outer canthi of the eyes, and the vertical electro-oculogram (VEOG) between electrodes placed above and below the left eye.

EEG analysis was conducted using EEGLAB (Delorme & Makeig, 2004). The EEG was bandpass-filtered offline (0.5-30 Hz). For the ERP analysis, EEG was re-referenced to the mean signal of the mastoid electrodes. ERPs were obtained by averaging 900-ms EEG epochs including a 100 ms pre-stimulus period and an 800-ms post-stimulus period. The mean voltage of the pre-stimulus period served as a baseline for amplitude measurements. Epochs contaminated by eye movements, or other extracerebral artifacts producing voltage changes exceeding a threshold value of $\pm 65 \mu\text{V}$ at any

electrode were omitted from averaging. Only data from the participants whose averaged auditory ERP contained more than 55% of the novel sound trials were included in further analyses of the auditory ERP and behavioral data. The group means of novel sound trials per condition included in the ERP average were 23.7 (standard deviation $SD = 4.5$) and 23.3 ($SD = 4.3$) trials for the job burnout and control group, respectively. Correspondingly, the data used in the visual ERP analysis were from the same participants as in the auditory ERPs except that in addition to that, data from one control participant was discarded due to technical difficulties in recording the visual ERPs. Only visual trials preceding correct responses to matched stimuli were analyzed. Based on the 0-back condition, the group mean of visual trials included in the ERP average was 42.3 ($SD = 18.2$) trials for the burnout group while for the control group it was 43.1 ($SD = 15.9$).

ERPs were averaged separately for each electrode site, stimulus type (i.e., auditory and visual), and n-back condition. For the auditory ERPs, the mean amplitudes of the two different phases of the P3a were computed using 100-ms time windows around the peak of each phase that were detected as the largest positivity in the two measurement windows (170-270 ms and 280-480 ms for the early and late phases, respectively). The early and late P3a were identified in the grand average signal of the 0-back condition across all participants. In order to evaluate early perceptual processing (Näätänen & Picton, 1987), the auditory N1 was determined as the most negative deflection in a time window of 50-150 ms from stimulus onset, and mean amplitudes were computed using 40-ms window centered at the peak latency. For the visual P3b, the measurement interval was 300-500 ms from stimulus onset. Individual peak latencies were measured from the largest peak occurring at the 100-ms period centered at the peak latency at Fz for the auditory, and Pz for the visual waveforms in the grand average signals in each condition.

Statistical analysis

Statistical analyses were carried out using the R software environment for statistical computing and graphics (version 3.0.3; Lawrence, 2013; R Core Team, 2014; Wickham, 2009). Amplitudes and latencies of the visual and auditory ERPs were analyzed using a mixed-design, repeated-measures analysis of variance (ANOVA) with Group (job burnout, control) as the between-participants factor, and Task Load (0-, 1-, 2-back condition) and Electrode Position (anterior, central, posterior) as the within-participant factors. In the analysis reported below, different subsets of electrodes were taken together to investigate the effects of job burnout on the topographical distribution of the auditory and visual ERPs. The anterior-posterior distribution of the auditory ERP analysis comprised the following electrode sites: anterior (F3, Fz, F4), central (C3, Cz, C4), and posterior (P3, Pz, P4). The corresponding electrode sites for the analysis of the visual ERPs were anterior (F3, F7, Fz, F4, F8, Fp1, Fp2), central (C3, Cz, C4, FC1, FC2), and posterior (P3, P7, Pz, P4, P8, CP1, CP2).

The assumption of sphericity was evaluated using Mauchly's procedure and when violated, the Greenhouse-Geisser correction was used to adjust the degrees of freedom for the ANOVA F-distribution. In the results, we report F-value together with the original degrees of freedom, corrected p-value, Greenhouse-Geisser correction factor epsilon, and the effect sizes using generalized eta squared (Olejnik & Algina, 2003; Picton et al., 2000). After finding a significant main effect or interaction, post-hoc *t*-tests were carried out to investigate the pairwise effects. The *p*-values were adjusted using the Holm-Bonferroni method for multiple comparisons. All main effects (i.e., significant and non-significant main effects) are reported, whereas for the interaction effects, only significant and nearly significant effects are reported. For the analysis of the behavioral data, a correct button press within 200-1999 ms after the onset of the visual stimulus was regarded as a hit. The hit rates were calculated from the silent trials (i.e., not preceded or followed by a distractor sound), and compared by means of repeated-measures ANOVA with Group (burnout, control) as the between-participants factor and Task Load (0-, 1-, 2-back) as the within-participant

factor. The effect of the distractor sounds on the hit rates was not calculated as the number of “distractor present” trials and especially the number of false and missed responses among them were small. However, for the means of the median RTs of the correct responses, a repeated-measures ANOVA with Group as the between-participants factor, and Task Load and Auditory Distractor (present, absent) as the within-participant factors was performed. Visual stimuli were defined as “distractor present” when preceded or followed by a distractor sound (i.e., occurred in a stimulus-response chain of “Picture – Sound – Response”, or “Sound – Picture – Response”; Figure 1). We chose to use subjective sleepiness ratings (KSS scores in the beginning of the whole recording session and prior to the n-back recordings) as well as symptoms of anxiety (BAI score) as covariates in the analyses to ensure that they would not account for group differences in the ERP or behavioral results.

Results

Characteristics of the two participant groups are presented in Table 1. The self-reported prescribed medication within 24 hours prior to the ERP recordings was as follows: medication for sleep disturbances 7% and 0%, and mood disorders 27% and 17% for the job burnout and control groups, respectively. In addition, caffeine consumption 24 hours before the recordings was comparable between the groups (Median value for both groups: 1-3 cups of caffeinated drinks; $t_{46} = -0.81$, $p = 0.42$).

Behavioral data

The hit rates were comparable between the burnout and control groups ($F_{1,47} = 1.55$, $p = 0.22$). As expected, the main effect of Task Load was significant ($F_{2,94} = 152.39$, $p < 0.001$, $\epsilon = 0.56$, $\eta^2 = 0.66$). The overall hit rate decreased as the task became more demanding (0-, 1-, 2-back: 93.1%, 88.7%, 72.8%, respectively; Holm-Bonferroni: 0-back vs. 1-back; 1-back vs. 2-back, $p < 0.001$). The interaction between Group and Task Load was not significant.

RTs did not differ between the groups ($F_{1,47} = 0.05, p = 0.80$) but the main effect of Task Load was significant ($F_{2,94} = 61.44, p < 0.001, \epsilon = 0.55, \eta^2 = 0.35$). As expected, RTs became longer with increasing cognitive load (0-back vs. 1-back; 1-back vs. 2-back, $p < 0.001$). The main effect of distraction caused by presenting novel sounds was significant ($F_{1,47} = 55.74, p < 0.001, \eta^2 = 0.01$). Pairwise comparison revealed that RTs only tended to be longer on distracted trials than on silent trials not preceded or followed by a novel sound (Holm-Bonferroni, $p = 0.08$) indicating a trend towards a distracting effect of novel sounds over the performance on the visual task. The interaction between Task Load and Auditory Distractor (present vs. absent) was significant ($F_{2,94} = 10.1, p = 0.007, \epsilon = 0.70, \eta^2 = 0.005$) but no significant differences in the distracting effects were observed in pairwise comparisons.

ERP data

In both groups, auditory novelty-related electrophysiological activity was characterized by an N1 wave, followed by a large P3a response. In the 0-back condition, the N1 peaked at 106 and 104 ms at the midline frontal site (i.e., Fz) for the burnout and control group, respectively. Also at the midline frontal site, the early P3a peaked at 220 ms and 218 ms post-stimulus whereas the late P3a peaked at 302 ms and 294 ms for the job burnout and control groups, respectively. For the visual ERPs, trials preceding correct responses elicited a large P3b response, peaking at 377 ms and 367 ms at midline parietal site (i.e., Pz) for the burnout and control groups, respectively.

Scalp potential distribution mapping of the auditory responses showed that the early P3a was maximal over the central scalp regions whereas the late phase was distributed over fronto-central regions (Figure 2). The visual P3b was maximal over the centro-parietal scalp regions when the task load was the lowest. With higher task loads, the amplitude of the P3b was decreased in comparison

with the low-load condition, and the amplitude maximum shifted towards more posterior parietal scalp regions (Figure 3).

Auditory ERPs

Figure 2b shows the grand average waveforms of the auditory responses. For the N1 mean amplitude, the main effect of Group was not significant ($F_{1,47} = 0.02, p = 0.89$) nor was the main effect of Task Load ($F_{2,94} = 0.91, p = 0.40$). As expected, the main effect of Electrode Position (anterior, central, posterior) was significant ($F_{2,94} = 20.74, p < 0.001, \epsilon = 0.70, \eta^2 = 0.05$). The N1 mean amplitude was the largest over the central region, intermediate at frontal, and the smallest over the posterior region (pairwise comparisons: anterior < central, $p < 0.001$; central > posterior, $p < 0.001$; anterior > posterior, $p = 0.007$). No significant interactions were observed. The N1 peak latencies were comparable between the groups ($F_{1,47} = 2.22, p = 0.14$), and the main effect of Task Load approached significance ($F_{2,94} = 3.00, p = 0.06$). The interaction between Group and Task Load was not significant.

As for the N1, the main effect of Group and Task Load on the early P3a mean amplitudes were not significant (Group: $F_{1,47} = 1.85, p = 0.18$; Task Load: $F_{2,94} = 0.31, p = 0.73$). As expected, the early P3a was larger over the anterior-central region (main effect of Electrode Position: $F_{2,94} = 90.42, p < 0.001, \epsilon = 0.69, \eta^2 = 0.16$), and smaller at the posterior scalp (Holm-Bonferroni: anterior vs. central: $p = 0.87$; anterior vs. posterior: $p < 0.001$, central vs. posterior: $p < 0.001$). The interaction between Group and Task Load was significant ($F_{2,94} = 3.11, p = 0.049, \epsilon = 0.99, \eta^2 = 0.01$). As compared with the control group, the job burnout group showed smaller amplitudes in the 2-back condition ($p < 0.001$) while in the 0- and 1-back conditions the responses were comparable between the groups ($p = 0.34, p = 0.95$, respectively). No other significant interactions were observed. The early P3a peak latencies were not affected by the groups ($F_{1,47} = 0.22, p = 0.64$), or the task loads ($F_{2,94} = 2.33, p = 0.11$). The interaction between Group and Task Load was not significant.

For the late P3a, the ANOVA revealed a main effect of Group ($F_{1,47} = 4.34, p = 0.04, \eta^2 = 0.05$), the responses being smaller in the burnout group (Figure 4). Further, the main effects of both Task Load and Electrode Position were also significant ($F_{2,94} = 16.42, p < 0.001, \varepsilon = 0.93, \eta^2 = 0.09$; $F_{2,94} = 31.64, p < 0.001, \varepsilon = 0.57, \eta^2 = 0.08$, respectively). The late P3a was the largest in the 0-back condition, intermediate in the 1-back and smallest in the 2-back condition (pairwise comparisons: 0-back > 1-back: $p < 0.001$; 0-back > 2-back: $p < 0.001$; 1-back > 2-back: $p = 0.049$). In addition, the amplitudes were the largest at anterior scalp location, decreasing towards central and posterior regions (anterior > central: $p = 0.04$; anterior > posterior, $p < 0.001$; central > posterior: $p < 0.001$). No significant interaction effects were observed. The late P3a peak latencies were comparable between the groups ($F_{1,47} = 1.37, p = 0.25$), and the task loads ($F_{2,94} = 1.62, p = 0.20$). The interaction between Group and Task Load was not significant.

Visual ERPs

Figure 5 shows the group mean P3b. The main effect of Group was not significant ($F_{1,46} = 2.21, p = 0.14$). However, the main effect of Task Load was significant ($F_{2,92} = 37.47, p < 0.001, \varepsilon = 0.87, \eta^2 = 0.12$), with the P3b amplitudes becoming smaller as the task load increased (0-back > 1-back > 2-back, $p < 0.001$). As expected, there was a significant main effect of Electrode Position ($F_{2,92} = 61.14, p < 0.001, \varepsilon = 0.68, \eta^2 = 0.15$), with the most pronounced responses at posterior and central regions, becoming smaller towards anterior regions (posterior > anterior, central > anterior, $p < 0.001$; posterior vs. central, $p = 0.056$). Notably, there was a significant interaction between Group and Electrode Position ($F_{2,92} = 4.39, p = 0.03, \varepsilon = 0.68, \eta^2 = 0.01$). Pairwise comparisons revealed that for the burnout group, the responses were smaller over the posterior ($p = 0.002$) and central ($p = 0.03$) regions, but larger over the anterior ($p = 0.003$) regions than for the control group. The interaction between Task Load and Electrode Position was also significant ($F_{4,184} = 7.45, p < 0.001, \varepsilon = 0.69, \eta^2 = 0.004$). The responses were the most pronounced at central and posterior scalp when

the task load was the lowest, decreasing as a function of increase in task load, and the smallest at anterior regions also decreasing with an increase in task load. The interaction between Group, Task Load, and Electrode Position did not reach significance ($F_{4,184} = 2.56, p = 0.06$). The P3b peak latencies did not differ between the groups ($F_{1,46} = 0.18, p = 0.67$). Task Load, in turn, had an effect on the peak latencies ($F_{2,92} = 5.62, p = 0.006, \varepsilon = 0.93, \eta^2 = 0.05$), with the shortest latencies for the highest task load (0-back > 2-back, $p = 0.009$) while the latencies in the 0- and 1-back conditions were comparable (0-back vs 1-back, $p = 0.4$; 1-back vs. 2-back, $p = 0.09$). The interaction between Group and Task Load was not significant.

Discussion

At work, the ability to remain focused on a given task is essential even in the presence of potentially interfering distractors such as background noise. At the same time, orienting to salient, sudden changes in the environment is essential, too, providing crucial information for coping in unexpected situations. In the present study, we assessed whether job burnout is associated with alterations in cognitive task performance and cortical evoked responses. Specifically, we assessed the impact of burnout symptoms on performing a cognitive task with varying memory loads, and on involuntary orienting of attention to auditory stimulation unrelated to task. Previously reported cognitive changes in the literature regarding job burnout are mostly from behavioral studies, but to the best of our knowledge, the possibility of electrophysiological alterations has only been under little discussion.

The present results from our sample of job burnout participants with relatively mild burnout showed an association between job burnout and alterations in attention-related auditory and visual ERPs. The results were significant at a group level, although with relatively small effect sizes. Unique distractor sounds, categorically different from the context, elicited a two-phasic P3a response that

was reduced in amplitude in the burnout group. More precisely, the auditory early P3a was smaller in the burnout group when the cognitive load of the visual working-memory task was high, and the late P3a was reduced across all task loads. The N1, traditionally interpreted as an indication of early perceptual processing in primary and associative auditory cortices, was comparable between the groups (Näätänen & Picton, 1987). The visual P3b responses elicited by the task-relevant stimuli differed between the groups as a function of the topographical distribution. The job burnout group showed an attenuation of the P3b at posterior regions but an amplification of the response at anterior regions as compared with those of the control group. Behavioral results showed that the burnout group maintained equally high levels of task performance as the control group as reflected by comparable reaction times and error rates when auditory distractors were present. Conceivably, high levels of burnout symptoms might be required for impaired cognitive task performance to be observed (Linden et al., 2005; Oosterholt, Maes, Van der Linden, Verbraak, & Kompier, 2014; Sandström et al., 2005). Importantly, despite the apparent ability to maintain task performance while having burnout symptoms, the electrophysiological results suggest disruptions in information-processing, in line with the study of van Luitelaar et al. (2010).

As expected, the distractor sounds elicited significant P3a responses consistent with the involuntary capture of attention triggered to these novel stimuli. The P3a waveform has been proposed to be an essential marker of the orienting response, the rapid and involuntary shift of attention towards a novel stimulus (Knight, 1984; Soltani & Knight, 2000). It has been argued that the more salient the distractor sound is, the larger is the P3a response, supporting the notion that larger P3a responses indicate stronger orienting of attention (Escera et al., 2003). Moreover, the results showed that when the task load increased, the late phase of the P3a to the distracting sounds attenuated in both groups. This is in accordance with previous studies showing that when the visual task is made more challenging, for example by imposing higher load into working memory, especially the late P3a elicited by deviant or novel sounds is attenuated, thereby suggesting that involuntary attention

switching to distracting auditory stimulation is modulated by top-down mechanisms (Berti & Schröger, 2003; Escera & Corral, 2007; SanMiguel et al., 2008). Importantly however, the late P3a responses were smaller in the burnout group than in the control group across all memory loads, and the early P3a was reduced with the highest memory load. These results suggest that orienting to task-irrelevant but potentially significant distinct events in the acoustic environment is insufficient in job burnout, in accordance with the study of Knight (1984) where decreased P3a responses were demonstrated in patients with prefrontal lesions. Furthermore, our findings suggest that the more the working memory is taxed, the more ineffective the orienting of attention is in job burnout.

In addition to attenuation of responses to the distractor stimuli, we observed divergent P3b responses to task-relevant stimuli between the groups. The task-related decrease at posterior scalp sites and the simultaneous increase at frontal sites might be an indication of dysfunctional cognitive control processes at fronto-parietal regions in job burnout. Similar observations of a frontally oriented P3b has been shown in older adults (Fabiani, Friedman, & Cheng, 1998; Friedman, Kazmerski, & Fabiani, 1997). Friedman and colleagues (1997) suggested that in older and young adults the P3b scalp distribution is modulated by similar mechanisms, consistent with a large body of evidence of volitional target detection and working-memory updating processes (e.g., Soltani & Knight, 2000). They further proposed that in older adults the modulation is superimposed on frontal scalp positivity suggesting that older adults still depend on frontal regions for processing stimuli that have already been well encoded in young adults. Furthermore, fronto-parietal dysfunctions have been also suggested in relation to stress (Arnsten, 2009; Shackman et al., 2011), anxiety (Bishop, 2007), and sleep fragmentation (Kingshott, Cosway, Deary, & Douglas, 2000). Perhaps, in order for the burnout participants to be able to maintain equally good performance as the controls, as in the present study, additional recruitment of anterior brain regions might be required to compensate the posterior decrement of the P3b.

Recently, neuroimaging studies have started to provide evidence on the neural underpinnings related to job burnout. For instance, Blix, Perski, Berglund, and Savic (2013) reported regional reductions in the gray-matter volumes of the anterior cingulate cortex and dorsolateral prefrontal cortex as well as in the volumes of caudate and putamen in chronic work-related stress, indicating a morphological involvement of the frontostriatal circuits. In the study of Jovanovic, Perski, Berglund, and Savic (2011), participants with chronic work-related stress displayed dysfunctions in limbic networks, more specifically a functional disconnection between the amygdala and anterior cingulate/medial prefrontal cortex, suggesting an impaired top-down regulation of stress stimuli.

However, as job burnout is a heterogeneous syndrome-like condition (Maslach et al., 2001), the present findings should be interpreted cautiously. Indeed, our sample of job burnout participants reported a wide range of symptoms, however relatively mild on average. Therefore, one might question whether the results reflect overlapping conditions such as sleep disturbances, anxiety, or depression. Although we statistically controlled for both the experienced sleepiness during the recording session and the symptoms of anxiety, the contribution of other overlapping elements such as nighttime sleep disturbances, or depressive symptoms on the results cannot be assessed without difficulty. Especially dysphoric symptoms such as fatigue, inability to concentrate, difficulty relaxing off work, and distancing are overlapping characteristics between burnout and depression. In their recent study, Ahola et al. (2014) suggested a conceptual similarity between burnout and depressive symptoms in the work-context. Indeed, it has been suggested that adverse psychosocial factors at work are associated with elevated risk for the development of burnout and depressive symptoms (Bonde, 2008; Borritz et al., 2005). Depression, however, is non-specific in nature, and can develop in any domain of life influencing all aspects of life, including work (e.g., Bakker et al., 2000).

In addition, as the self-reported medication for sleep disturbances and mood disorders were found to be fairly low and comparable between the groups, we are confident that medication had little impact on the findings reported here. Furthermore, both groups can be considered representative of working life in Finland as the participants in the present study were currently working and not diagnosed with clinical severe depression or anxiety disorders, or sleep problems (Ahola et al., 2006).

Taken together, the present results suggest that at group level job burnout is associated with alterations in cortical evoked responses during task performance. We observed that in burnout, orienting of attention to irrelevant, but potentially significant unexpected novel events in the acoustic environment is decreased during task performance. We also observed divergent task-related responses between the groups as a function of topographical scalp distribution. Perhaps in job burnout, even though task performance can be maintained at a similar level as the controls, additional recruitment of anterior regions might be required to compensate for reduced posterior activity. Together these results suggest that job burnout is associated with dysfunctional cognitive control processes at fronto-parietal regions. The present study provides new insight on electrophysiological correlates related to job burnout in tasks that require information monitoring and context updating as well as filtering out irrelevant information, and may partially explain the cognitive problems experienced by the individuals with burnout symptoms despite the comparable task performance. However, as brain research related to burnout is only arising, further research is needed to replicate and extend these findings to a larger sample in order to evaluate the impact of the severity of the burnout symptoms on the differences in the attention-related activity. Also follow-up studies are needed to better understand the impact of the time-course of burnout symptoms on cortical brain responses. The results of the present study are promising and are of potential value, e.g., when developing and organizing work in safety-critical occupations.

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Figure Captions

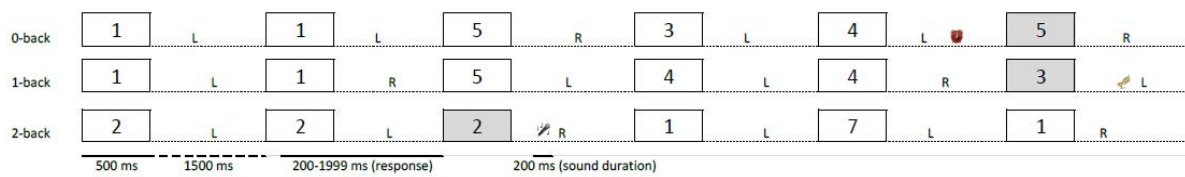
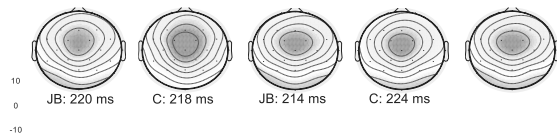


Figure 1. Schematic illustration of the experimental design. Each condition comprised 212 visual stimuli, 33% of them being matches in the 0-back, 1-back, and 2-back task. During the visual tasks, ninety-six distracting novel sounds were presented, thirty-two in each n-back condition, once every 10-16 seconds. Participants were instructed to concentrate on the visual task, respond to every visual stimulus, and ignore the sounds. The uppermost row illustrates the 0-back condition, the middle row the 1-back condition, and the undermost row the 2-back condition. The gray toned visual stimuli are preceded or followed by a distractor sound. L = correct response with the left button press R = correct response with the right button press

A Voltage distribution maps



B Grand-average waves

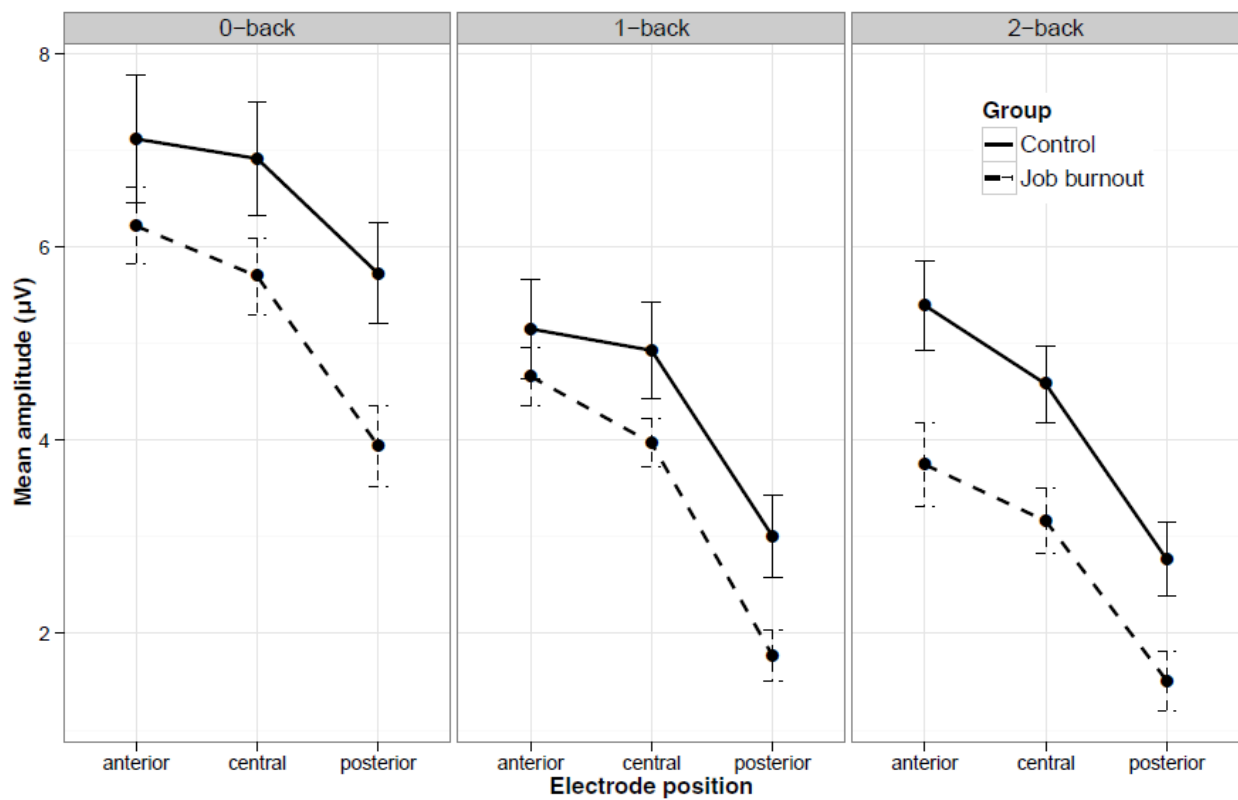


Figure 4. Line plots showing the group mean amplitudes (μV) with standard errors of the auditory late P3a for both groups at anterior, central, and posterior scalp.

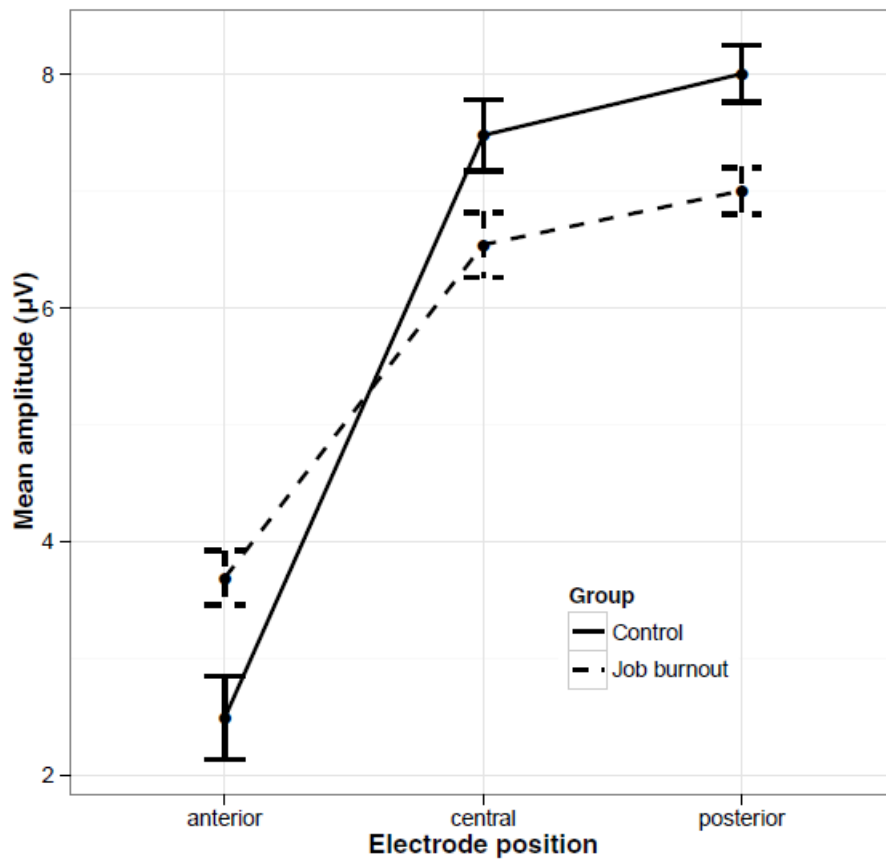


Figure 5. Line plots showing the group mean amplitudes (μV) with standard errors of the visual P3b for both groups at anterior, central, and posterior scalp.

Tables

Table 1. The descriptive statistics of the participants included in the analysis ($n=49$) in the job burnout and control groups. Standard deviations are presented in parenthesis.

Variable	Job burnout	Control		
<i>N</i>	30	19		
Female / Male	27 / 3	15 / 4		
	Job burnout	Control		
	Mean (sd)	Mean (sd)	t-value	p value
Age	47.5 (8.2)	43.3 (8.7)	1.74	0.09
Education (in years)	15.5 (2.0)	15.2 (2.1)	0.54	0.59
Working experience (in years)	22.1 (10.5)	19.1 (13.9)	0.85	0.40
Job burnout score (MBI-GS)	3.1 (0.9)	0.9 (0.4)	9.92	<0.001
Exhaustion	3.93 (1.27)	0.84 (0.63)	9.86	<0.001
Cynicism	3.30 (1.52)	1.05 (0.84)	5.89	<0.001
Professional inefficacy	1.87 (1.26)	0.69 (0.53)	3.86	<0.001
Symptoms of anxiety (BAI)	9.5 (5.2)	3.7 (3.7)	4.16	<0.001
Depressive symptoms (BDI-II)	16.0 (6.2)	4.6 (5.2)	6.61	<0.001
Subjective sleepiness ¹ (KSS)	4.9 (1.3)	4.3 (1.8)	1.24	0.22
Subjective sleepiness ² (KSS)	4.0 (1.3)	2.9 (1.0)	2.93	0.005
Sleep disturbances (BNSQ)	3.1 (1.9)	1.7 (1.6)	2.72	0.009

Note: MBI-GS = Maslach Burnout Inventory – General Survey; BAI = Beck's Anxiety Inventory; BDI-II = Beck's Depression Inventory; KSS = Karolinska Sleepiness Scale; BNSQ = Basic Nordic Sleeping Questionnaire.

¹KSS rating in the beginning of the whole recording session

²KSS rating prior to the n-back recordings